

## Earthquake Information

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**Program Element:** II/A (Earthquake Information/Seismic Monitoring)

**Keywords:** Source characteristics, Seismotectonics, Information transfer, Real-time earthquake information

### Investigations undertaken

**I. Routine Operations:** This project task has two basic responsibilities: operation of the Earthquake Early Alerting Service (EEAS) and publication of earthquake data. The primary responsibility is to operate the EEAS, providing information about important earthquakes whenever they occur. This service is manned 24 hours a day and requires the National Earthquake Information Center (NEIC) to determine the location and magnitude of important earthquakes within the United States and around the world as rapidly and as accurately as possible, and to communicate this information to interested persons or groups. The second responsibility is to produce earthquake data publications that are used throughout the world for nuclear test ban treaty monitoring and basic seismological research including hazard assessment, earthquake prediction, tectonics, and source mechanisms. To prepare these publications, data are received from about 2,000 seismograph stations throughout the world. Quick Epicenter Determinations (QED) is a daily publication of earthquakes which is available by computer bulletin board, electronic mail, and the World-Wide Web (WWW), and reports about 10-15 events per day. The PDE is a weekly publication that lists the location, magnitude, and felt effects of about 175 earthquakes. It is followed about four months later by the Monthly Listing and the Earthquake Data Report (EDR). All earthquakes published in the Monthly Listing are recomputed using two to three times more data than was available at the time of publication of the PDE. At the same time, many additional earthquakes, which had insufficient data to be published in the PDE are located and included. The EDR shows all data used to compute the earthquake locations published in the Monthly Listing. Approximately 1,500 to 2,000 events are published in each Monthly Listing and EDR. Significant Earthquakes of the World is a listing updated every two

weeks that gives information about earthquakes that were of magnitude 6.5 or greater or that have caused casualties or substantial damage.

**II. Earthquake Information Products and Outreach:** This project task contributes data and information for use in all phases of earthquake research as well as printed and visual information for the non-scientific user. The data are used in seismic-risk studies, source-parameter studies, seismicity studies, and in such areas as insurance, education and public information. The NEIC data augment data collected by the U.S. Atomic Energy Detection System for purposes of monitoring global compliance with nuclear test ban treaties, and the NEIC data will play an important role in the implementation of the Comprehensive Test Ban Treaty. The products are available in many formats, including paper listings, magnetic tape, diskette, CD-ROM, USGS publications, maps, film or microfiche, and via the Internet. These products are used throughout the nation and world by scientists, lawyers, geotechnical consultants, insurance companies, universities, governments, and citizens. This project task interacts with most internal and external projects that make use of hypocentral data, digital seismographic data, or intensity data.

**III. Technology Transfer:** To achieve the goal of continually improving and expanding these products, this part of the project focuses on three tasks. (1) Refine the models of velocity and attenuation of the Earth that are used in the computation of source parameters. Having better velocity models of the Earth, the NEIC is able to compute more accurate earthquake locations. Similarly, improvements in understanding of effects of wave propagation on waveforms enables the NEIC to compute more accurate estimates of earthquake size, such as magnitude, moment, and energy release. (2) Develop theories and methods for characterizing the earthquake source. To understand the effect of an earthquake on regional earthquake potential we also need to know, at a minimum, the static and dynamic characteristics of an earthquake, its complexity and geometry of rupture, and its associated stresses. With the broadband digital data that are now routinely available for most large earthquakes, the rupture process can be modeled in unprecedented detail. (3) Support NEIC data services by transferring the results of research into operational practice. This involves development and implementation of software for new algorithms, and upgrading of software for methods already in use. This project task includes efforts to improve NEIC services by encouraging international cooperation in the exchange of both digital and analog information.

## **Results**

**I. Routine Operations:** While the work and the products described in the “Investigations Undertaken” section above continues, we also continue the task of bringing NEIC procedures up-to-date. In particular, we are developing and implementing a new analysis software package that brings together many of the advances described in the “Technology Transfer” section. This software package incorporates the use of new, more accurate Earth models, secondary seismic phases, and is more flexible, allowing easier incorporation of further improvements. A new system for 24-hour operation of the EEAS, utilizing laptop computers and cellular technology, that reduces stress on the analysts, is also being developed. The ongoing transition to electronic data collection and distribution has allowed us to reduce printing costs. As this transition continues we expect to reduce these costs further.

**II. Earthquake Information Products and Outreach:** We continue to augment the rapid response capabilities of the NEIC by expanding the type of information available immediately following significant earthquakes to include descriptions of the rupture process, seismotectonic framework, rapid ground-motion estimates, aftershock probabilities, and improved graphical materials.

Postal canvasses of felt earthquake intensities are conducted for regionally significant earthquakes. The intensity data and isoseismal maps prepared therefrom are maintained in an electronic database and put on the web. In addition to data collected from postal canvasses of the most significant earthquakes, the electronic database contains intensity observations collected by or volunteered to the NEIC for the less significant shocks. We are exploring the use of data contributed voluntarily by e-mail to obtain intensities. Eventually, the electronically collected data will completely replace the postal questionnaires.

We produce and distribute outreach products displaying national and global seismicity information, including a global earthquake atlas. The aim of these products is to provide the most complete picture possible of where earthquakes have occurred historically in relation to geographic, geomorphic, and cultural features. These products are distributed to the research community worldwide, as well as to numerous educational institutions in the U.S.

We are determining how data produced or handled by the NEIC can be used to improve the effectiveness of both non-classified international monitoring of the Comprehensive Test Ban Treaty (CTBT) and classified U.S. monitoring of the CTBT. One general goal of this work is to determine and publish accurate hypocenters and magnitudes of U.S. seismic events (both natural and man-made) that a foreign power might suspect of being a clandestine U.S. nuclear test; this research is directed towards the “confidence building” element of the CTBT. A second general goal is to determine and publish accurate source parameters for foreign seismic events that might be nuclear tests conducted in violation of the CTBT. We have developed a system for producing routine bulletins of mine and quarry explosions in the U.S. using methodologies and geophysical knowledge that are considered established in the seismological community but that are not yet used routinely in the NEIC production of bulletins.

**III. Technology Transfer:** We continue to provide more accurate earthquake locations, primarily by developing improved procedures for hypocenter determination and better velocity models of the Earth. We are introducing several newly developed and tested procedures for the routine determination of hypocenters by NEIC: (1) ak135 or a closely-related model is being adopted as the one-dimensional reference model; (2) a statistical phase identification algorithm is being applied to later arriving phases, permitting these later phases to be confidently included with first arriving P waves in all hypocenter determinations; (3) work is continuing on the introduction of a realistic three-dimensional Earth model, with high resolution of subduction zone structures, and on the use of fast non-linear ray-tracing techniques for routine earthquake location.

We are testing and implementing new methodologies for the timely derivation and dissemination of extended source information based on real-time and near-real-time earthquake data. We are evaluating the feasibility of establishing an online automatic procedure to compute real-time or near real-time source mechanisms using regional waveform data.

We are continuing to refine the models of velocity and attenuation of the Earth used in the determination of earthquake size; individual tasks include (1) investigating the effects of lateral heterogeneity in the Earth; (2) refining frequency-dependent Q models by synthesizing waveforms using a method that simultaneously models causal attenuation and source finiteness; (3) applying

the resulting velocity and attenuation models to obtain more accurate estimates of radiated energy and seismic moment; (4) producing global and regional maps of accumulated energy release and apparent stress as a function of seismic region, tectonic environment, focal mechanism, and depth. As energy and moment data are accumulated, they will provide an important database in efforts to estimate seismic and tsunami hazard. We are further automating and otherwise accelerating the rapid moment tensor and energy determination procedures so that results are obtained in a time frame relevant to tsunami warning.

## **Non-technical Summary**

This project provides rapid earthquake information on felt earthquakes in the U.S. and significant earthquakes worldwide to federal and state government agencies, the national and international scientific communities, news media, and the general public. It integrates the national and global seismic monitoring effort of the National Earthquake Information Center (NEIC) with its outreach components, and with the research efforts designed to keep the analysis, processing, and outreach capabilities of the NEIC at state-of-the-art.

## **Reports published**

### ***Bulletins***

Early Earthquake Alerts, Daily QED, Weekly PDE, Monthly PDE and EDR

### ***World-Wide-Web***

NEIC earthquake hypocenter database (<http://wwwneic.cr.usgs.gov/NEIC/epic/epic.html>)

NEIC U.S. mine-blast database (<http://wwwneic.cr.usgs.gov/NEIC/mineblast>)

NEIC global seismograph station handbook (<http://wwwneic.cr.usgs.gov/NEIC/epic/epic.html>)

A compressed hypocenter data file with worldwide coverage of relocated events that are well-constrained teleseismically for the period 1964–1995, available by anonymous FTP.

### ***CD-ROMs***

Four waveform CD-ROMs

### ***Maps***

Tsunami-Generating Earthquakes Map, 1997, published by the National Earthquake Information Center.

Caribbean Seismicity Map, 1998, prepared by the National Earthquake Information Center and the Middle Americas Seismograph Consortium.

North America Natural Hazards Map, 1998, published by the National Geographic Society.

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**Data Availability**

Seismic data, including raw waveform data, arrival times and amplitudes of seismic phase data, and processed data in the form of seismic event catalogs are available in a variety of formats. Waveform data from the Global Seismograph Network (GSN), as well as from other networks participating in the Federation of Broadband Digital Seismograph Networks (FDSN), is available on CD-ROM. Phase and hypocentral data are available via CD-ROM, the World-Wide-Web, automated e-mail lists, and hard copy. For details contact Madeleine Zirbes, 303-273-8418, [zirbes@usgs.gov](mailto:zirbes@usgs.gov).